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(54) **TURBINE RING ASSEMBLY WITH RESILIENT RETENTION WHEN COLD**

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(57) **ABSTRACT**

A turbine ring assembly includes ring sectors made of ceramic matrix composite material forming a turbine ring, and a ring support structure having first and second annular flanges, each ring sector having tabs. The first tab includes an annular groove in which there is received an annular projection of the first flange. The second tab of each ring sector is connected to the ring support structure by a resilient retention element. The second tab includes an opening in which there is received a portion of a retention element secured to the second annular flange of the ring support structure. The retention element is made of a material having
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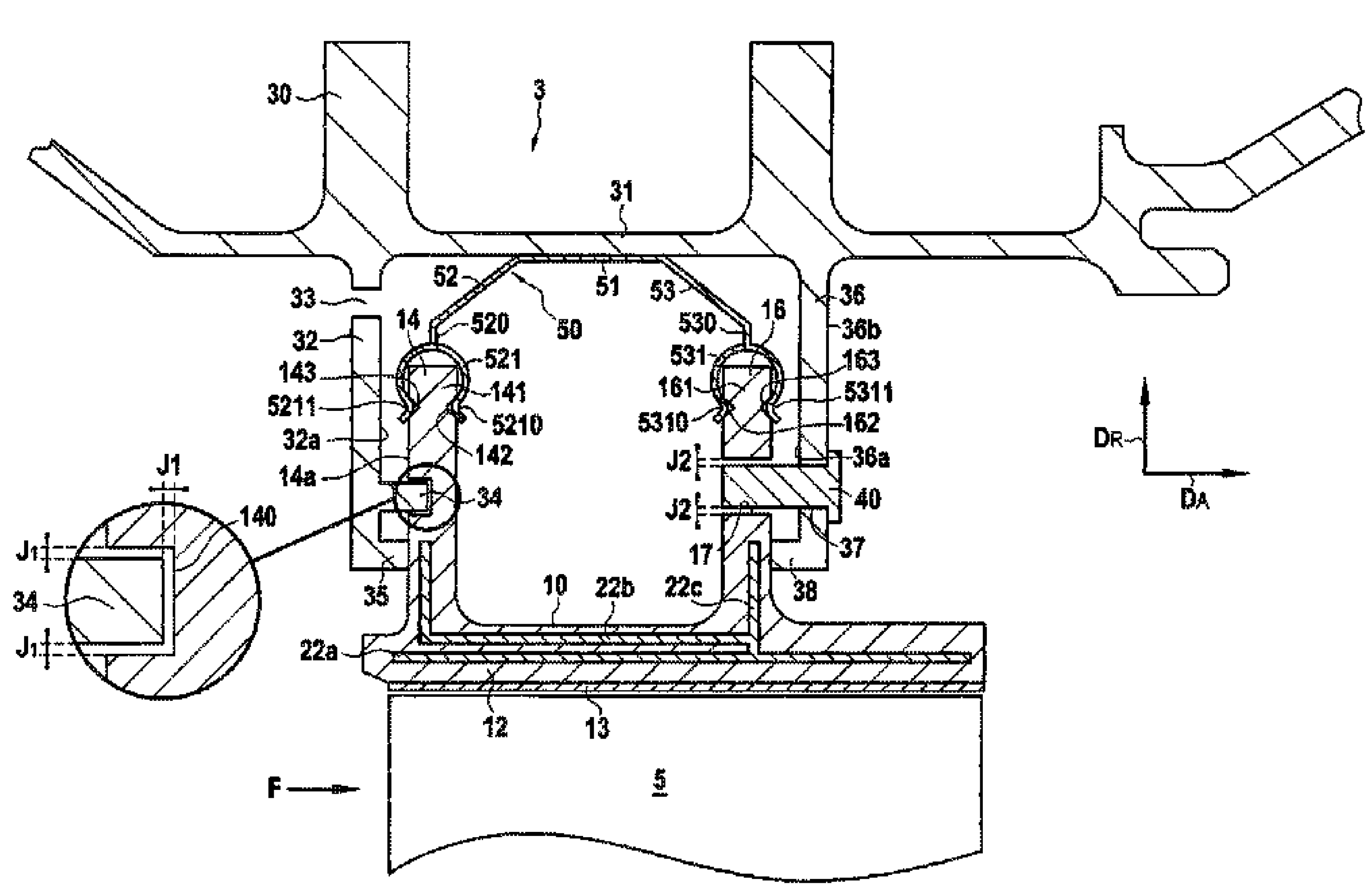

a coefficient of thermal expansion that is greater than the coefficient of thermal expansion of the ceramic matrix composite material of the ring sectors.

10 Claims, 6 Drawing Sheets

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F01D 25/24 (2006.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
CPC F01D 11/20; F01D 11/22; F01D 11/24; F01D 9/04; F05D 2240/11
See application file for complete search history.

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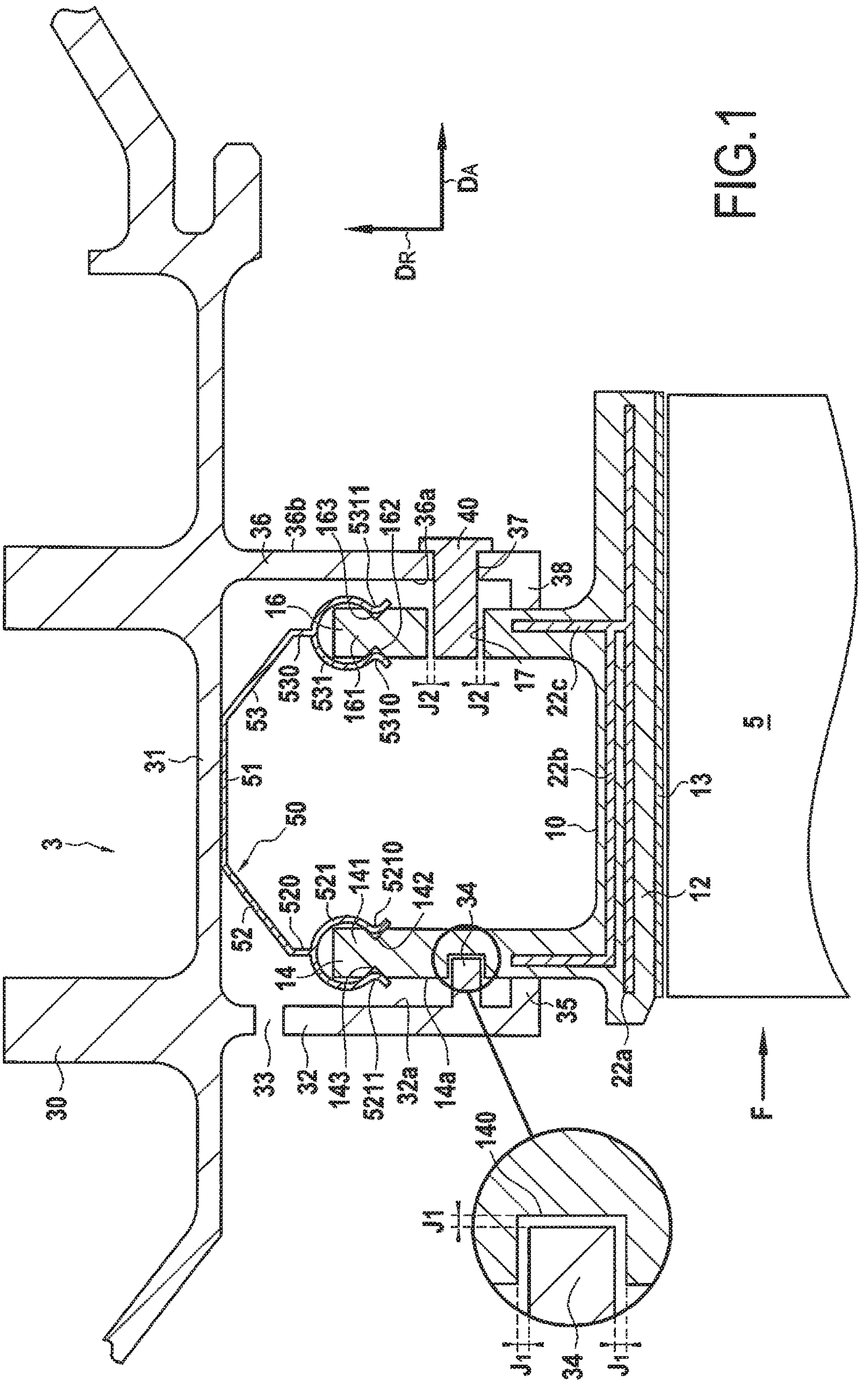
DA
DR
3
30
31
32
32a
33
34
35
36
36a
36b
37
38
40
5
10
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13
14
14a
16
17
22a
22b
22c
50
51
52
53
140
141
142
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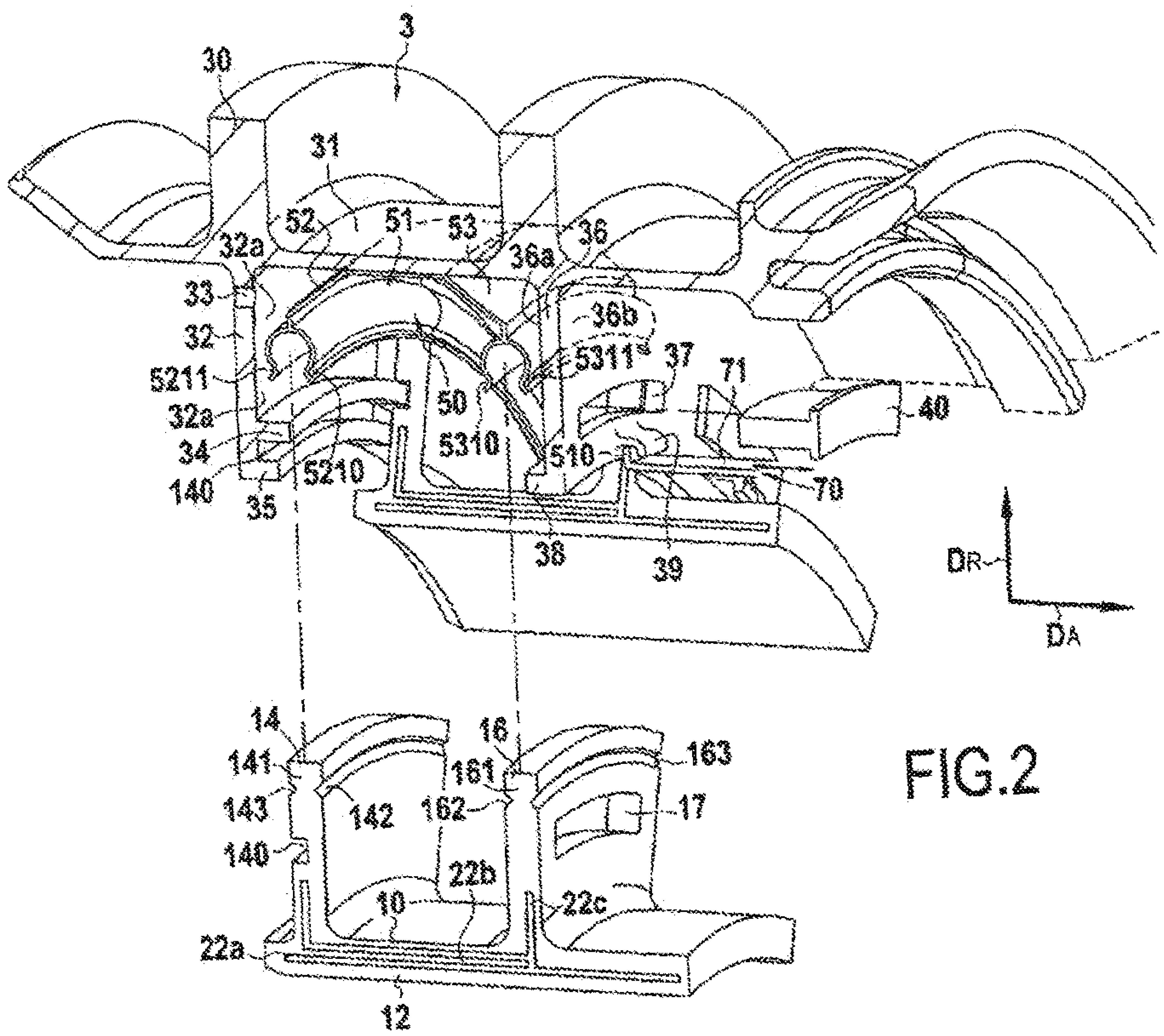
530
531
5210
5211
5310
5311
J1
J2
F

FIG. 1



3
30
31
52
51
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36
32a
36a
33
36b
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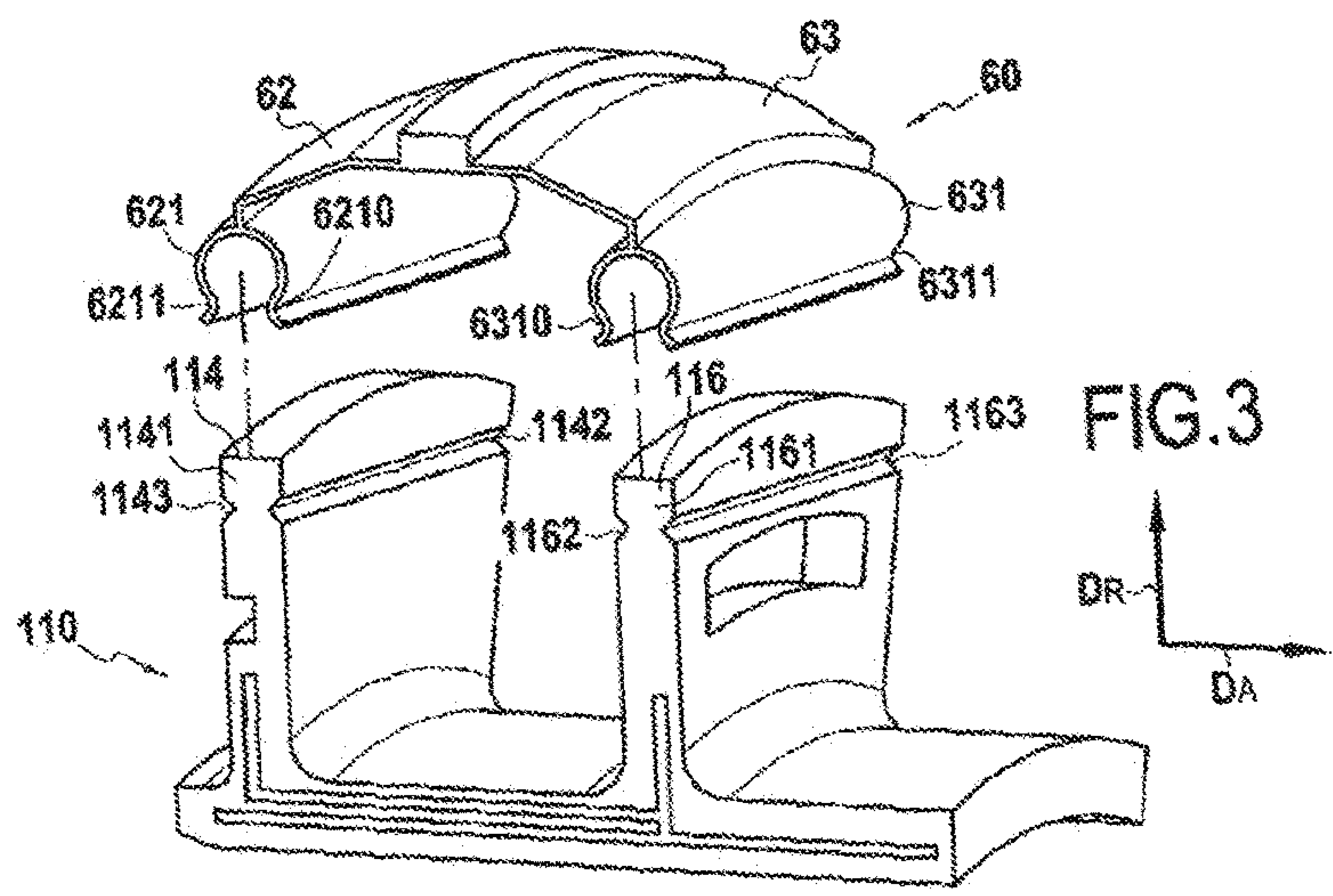
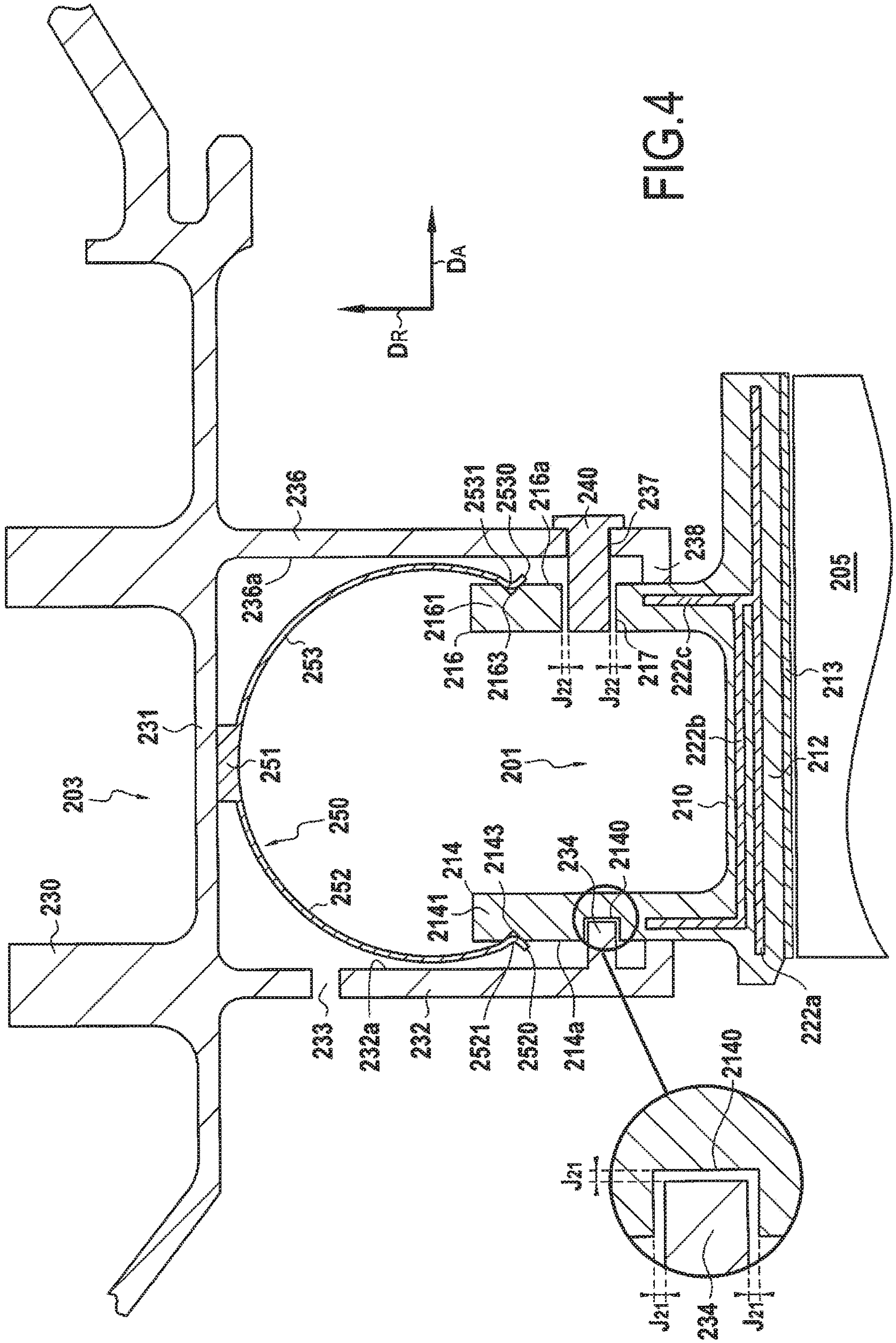
5311
37
5211
50
71
32a
40
34
5310
510
140
5210
70
35
38
39
DR
DA
14
16
163
141
161
143
142
162
17
140
22b
10
22c
22a
12

FIG.2



63
62
60
621
6210
631
6211
6310
6311
114
116
1141
1142
1161
1163
1143
1162
DR
110
DA

FIG.3



DA
DR
203
230
231
236
236a
251
250
252
253
233
232
232a
2521
2520
214a
2141
214
2143
234
2140
201
210
222b
212
213
222c
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J22
2163
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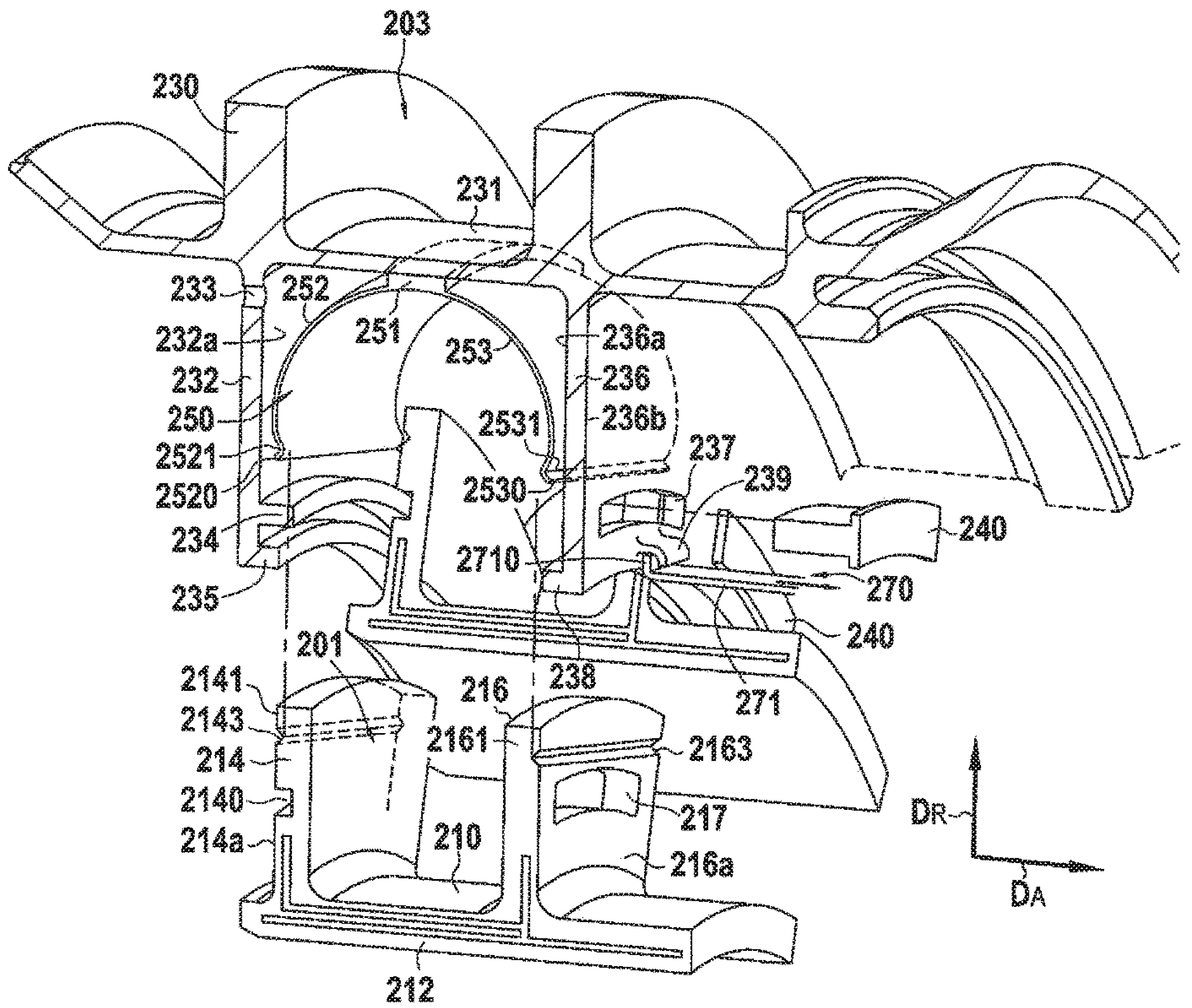
2161
2531
2530
216a
240
237
238
205
222a
J21

FIG. 4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234
240
2710
235
270
240
238
271
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2143
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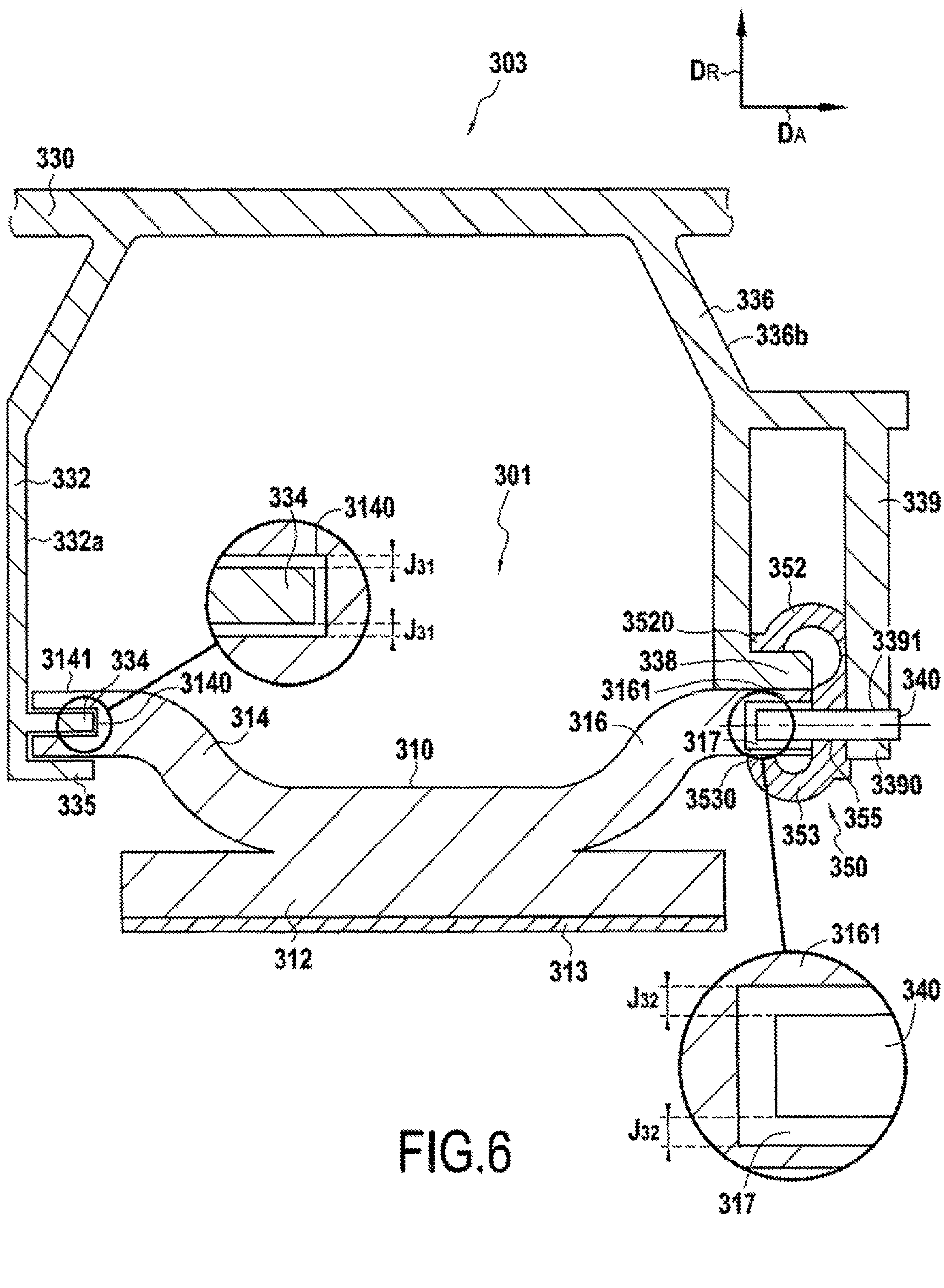
2163
214
2140
217
210
214a
216a
212
DR
DA

FIG.5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3141
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3140
338
3161
340
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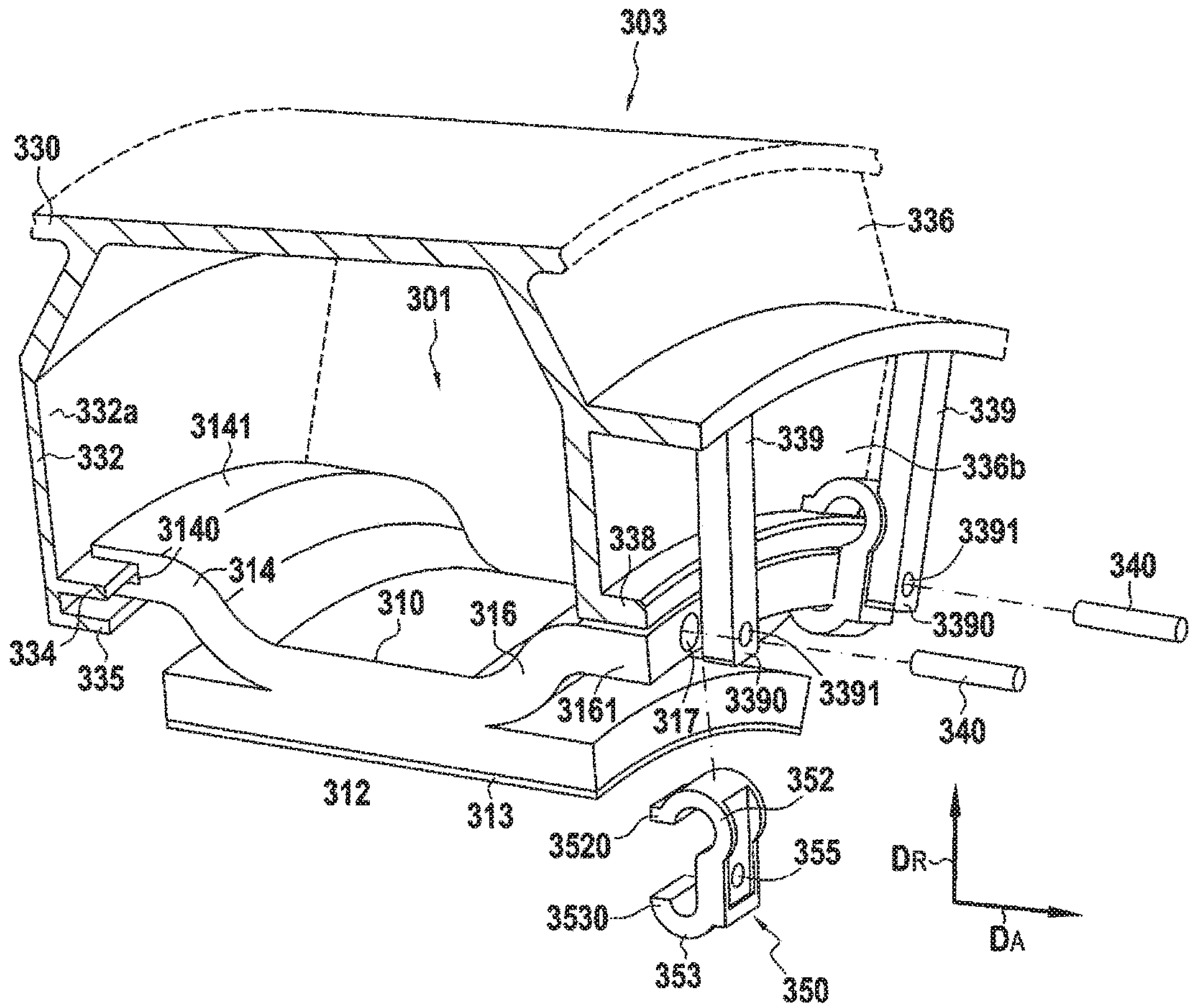
3161
J32
340
J32
317

FIG.6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336b
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3391
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335
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316
3390
3161
317
3390
3391
340
312
313
352
3520
355
DR
3530
DA
353
350

FIG.7

TURBINE RING ASSEMBLY WITH RESILIENT RETENTION WHEN COLD

CROSS REFERENCE TO RELATED APPLICATIONS

This application is the U.S. National Stage of PCT/FR2016/053343 filed Dec. 12, 2016, which in turn claims priority to French Application No. 1562745, filed Dec. 18, 2015. The contents of both applications are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

The field of application of the invention is particularly that of gas turbine aeroengines. Nevertheless, the invention is applicable to other turbine engines, e.g. industrial turbines.

Ceramic matrix composite (CMC) materials are known for conserving their mechanical properties at high temperatures, which makes them suitable for constituting hot structural elements.

In gas turbine aeroengines, improving efficiency and reducing certain polluting emissions lead to a search for operation at ever-higher temperatures. For turbine ring assemblies made entirely out of metal, it is necessary to cool all of the elements of the assembly, and in particular the turbine ring, which is subjected to streams that are very hot, typically hotter than the temperature that can be withstood by the metal material. Such cooling has a significant impact on the performance of the engine, since the cooling stream used is taken from the main stream through the engine. In addition, the use of metal for the turbine ring limits possibilities for increasing temperature within the turbine, even though that would improve the performance of aeroengines.

Furthermore, a metal turbine ring assembly deforms under the effect of hot streams, thereby changing clearances associated with the flow passage, and consequently modifying the performance of the turbine.

That is why proposals have already been made to use CMC for various hot portions of engines, particularly since CMCs present the additional advantage of density that is lower than that of the refractory metals conventionally used.

Thus, making turbine ring sectors as single pieces of CMC is described in particular in Document US 2012/0027572. The ring sectors have an annular base with its inner face defining the inside face of the turbine ring and an outer face from which there extend two tab-forming portions having their ends engaged in housings in a metal ring support structure.

The use of ring sectors made of CMC makes it possible to reduce significantly the amount of ventilation needed for cooling the turbine ring. Nevertheless, keeping or retaining ring sectors in position remains a problem in particular in the face of differential expansion, as can occur between a metal support structure and CMC ring sectors. In addition, another problem lies in controlling the shape of the passage both when cold and when hot without generating excessive stresses on the ring sectors.

OBJECT AND SUMMARY OF THE INVENTION

The invention seeks to avoid such drawbacks and for this purpose it provides a turbine ring assembly comprising a plurality of ring sectors made of ceramic matrix composite material forming a turbine ring and a ring support structure having first and second annular flanges, each ring sector having an annular base forming portion having an inner face defining the inside face of the turbine ring and an outer face from which there extend first and second tabs, the tabs of each ring sector being retained between the two annular flanges of the ring support structure; the turbine ring assembly being characterized in that the first tab of each ring sector includes an annular groove in its face facing the first annular flange of the ring support structure, the first annular flange of the ring support structure including an annular projection on its face facing the first tab of each ring sector, the annular projection of the first flange being received in the annular groove of the first tab of each ring sector, clearance being present when cold between the annular projection and the annular groove; in that at least the second tab of each ring sector is connected to the ring support structure by at least one resilient retention element; and in that the second tab of each ring sector includes at least one opening in which there is received a portion of a retention element secured to the second annular flange of the ring support structure, clearance being present when cold between the opening in the second tab and the portion of the retention element present in said opening, said retention element being made of a material having a coefficient of thermal expansion that is greater than the coefficient of thermal expansion of the ceramic matrix composite material of the ring sectors.

In the ring assembly of the invention, the ring sectors are retained when cold by resilient retention means that enable the ring sectors to be mounted without prestress. The resilient retention means of the ring sectors no longer ensure retention when hot because they expand. When hot, the retention force is taken up by the expansion of the annular projection of the first flange and of the retention element(s), which expansion does not lead to stress on the annular sectors because firstly of the presence of clearance when cold between the annular projection of the first flange and the annular groove of the first tab of each ring sector, and secondly because of the clearance between the retention element(s) and the opening(s) in the second tab.

In an embodiment of the ring assembly of the invention, each ring sector is Pi-shaped in axial section, the first and second tabs extending from the outer face of the annular base forming portion, the resilient retention means comprising a base fastened to the ring support structure and from which first and second arms extend, each arm including a C-clip type resilient attachment portion at its free end, the free end of the first tab of each ring sector being retained by the resilient attachment portion of the first arm, while the free end of the second tab of each ring sector is retained by the resilient attachment portion of the second arm of the resilient retention means.

The use of C-clip type resilient attachment portions enables assembly to be performed cold with little stress. Contact between the ring sectors and the ring support structure is uniform, thereby enabling forces to be well distributed.

According to a particular characteristic of the ring assembly of the invention, the first tab of each ring sector includes an outer groove and an inner groove co-operating with the C-clip type resilient attachment portion of the first arm of the resilient retention means, the second tab of each ring sector including an outer groove and an inner groove co-operating with the C-clip type resilient attachment portion of the second arm of the resilient retention means.

The inner and outer grooves of the first and second tabs of each ring sector may present a radius of curvature similar to the radius of curvature of the C-clip type resilient attachment portions of the first and second arms of the resilient retention means. They may also be rectilinear in shape, the C-clip type resilient attachment portions of the first and second arms of the resilient retention means then extending in a rectilinear direction.

In an another embodiment the ring assembly of the invention, each ring sector is Pi-shaped in axial section, the first and second tabs extending from the outer face of the annular base forming portion, the resilient retention means comprising a base fastened to the ring support structure and from which there extend first and second arms together forming a C-clip type resilient attachment portion, the free end of the first tab of each ring sector being retained by the first arm, while the free end of the second tab of each ring sector is retained by the second arm of the resilient retention means.

The use of a C-clip resilient attachment portion makes it possible to perform assembly when cold with little stress. Contact between the ring sectors and the ring support structure is uniform, thereby enabling forces to be well distributed.

According to a particular characteristic of the ring assembly of the invention, the first tab of each ring sector includes an outer groove co-operating with the free end of the first arm of the resilient retention means, the second tab of each ring sector including an outer groove co-operating with the free end of the second arm of the resilient retention means.

The outer grooves of the first and second tabs of each ring sector may be rectilinear in shape, the free ends of the first and second arms of the resilient retention means extending in a rectilinear direction.

In yet another embodiment of the ring assembly of the invention, each ring sector presents a K-shape in axial section, the first and second tabs extending from the outer face of the annular base forming portion, the first tab having an annular groove at its first end in which there is received the annular projection of the first annular flange, the second tab of each ring sector being connected to the second flange via one or more resilient retention elements.

According to a particular characteristic of the ring assembly of the invention, the second tab of each ring sector is connected to the second annular flange of the ring support structure by one or more clip elements.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention can be better understood on reading the following description given by way of non-limiting indication and with reference to the accompanying drawings, in which:

FIG. **1** is a section showing an embodiment of a turbine ring assembly of the invention;

FIG. **2** is a diagram showing a ring sector being mounted in the ring support structure of the FIG. **1** ring assembly;

FIG. **3** is a diagrammatic perspective view showing a variant embodiment of the FIG. **1** ring assembly;

FIG. **4** is a section view showing another embodiment of a turbine ring assembly of the invention;

FIG. **5** is a diagram showing a ring sector being mounted in the ring support structure of the FIG. **4** ring assembly;

FIG. **6** is a section view showing another embodiment of a turbine ring assembly of the invention; and

FIG. **7** is a diagram shown a ring sector being mounted in the ring support structure of the FIG. **6** ring assembly.

DETAILED DESCRIPTION OF EMBODIMENTS

FIG. **1** shows a high pressure turbine ring assembly comprising a turbine ring **1** made of ceramic matrix composite (CMC) material and a metal ring support structure **3**. The turbine ring **1** surrounds a set of rotary blades **5**. The turbine ring **1** is made up of a plurality of ring sectors **10**, FIG. **1** being a view in radial section. Arrow DA shows the axial direction relative to the turbine ring **1**, while arrow DR shows the radial direction relative to the turbine ring **1**.

Each ring sector **10** is of cross-section that is substantially in the shape of an upside-down Greek letter Pi, or "π", with an annular base **12** having its inner face coated in a layer **13** of abradable material that defines the flow passage for the gas stream through the turbine. Upstream and downstream tabs **14** and **16** extend from the outer face of the annular base **12** in the radial direction DR. The terms "upstream" and "downstream" are used herein relative to the flow direction of the gas stream through the turbine (arrow F).

The ring support structure **3**, which is secured to a turbine casing **30**, comprises a resilient retention element or means **50** comprising a base **51** fastened on the inner face of the shroud **31** of the turbine casing **30**, and first and second arms **52** and **53** extending from the base **51** respectively upstream and downstream. The base **51** may be fastened to the inside face of the shroud **31** of the turbine casing **30**, in particular by welding, by pegging, by riveting, or by clamping using a nut-and-bolt type fastener member, orifices being pierced in the base **51** and the shroud **31** for passing such connection or fastener elements.

The first arm **52** has a C-clip type resilient attachment portion **521** at its free end **520**, which portion presents a radius of curvature. The resilient attachment portion **521** retains the free end **141** of the upstream tab **14** of each ring sector **10**. The free end **141** of the upstream tab **14** has inner and outer grooves **142** and **143** formed on either side of the tab **14** for co-operating with the resilient attachment portion **521**, the grooves **142** and **143** in this example presenting a radius of curvature similar to the radius of curvature of the resilient attachment portion **521**. Likewise, the second arm **53** has a C-clip type resilient attachment portion **531** at its free end **530**, this portion presenting a radius of curvature, and serving to retain the free end **161** of the downstream tab **16** of each ring sector **10**. The free end **161** of the downstream tab **16** has inner and outer grooves **162** and **163** formed in both sides of the tab **16** and co-operating with the resilient attachment portion **531**, the grooves **162** and **163** in this example presenting a radius of curvature similar to the radius of the curvature of the resilient attachment portion **531**.

The resilient retention element **50** may be made of a metal material such as a Waspaloy®, Inconel 718, or AM1 alloy. It is preferably made as a plurality of annular sectors so as to make it easier to fasten to the casing **30**. The resilient retention element **50** serves to retain the ring sectors **10** on the ring support structure **3** when cold. The term "cold" is used in the present invention to mean the temperature at which the ring assembly is to be found when the turbine is not in operation, i.e. an ambient temperature, which may for example be about 25° C.

The ring support structure **3** has an upstream annular radial flange **32** with a first projection **34** on its inner face **32***a* facing the upstream tabs **14** of the ring sectors **10**, the projection **34** being received in an annular groove **140** present in the outer face **14***a* of the upstream tabs **14**. When cold, clearance J1 is present between the first projection **34** and the annular groove **140**. The expansion of the first projection **34** in the annular groove **140** contributes to retaining ring sectors **10** on the ring support structure **3** when hot. The term "hot" is used herein to mean the temperatures to which the ring assembly is subjected while the turbine is in operation, which temperatures may lie in the range 600° C. to 900° C.

The upstream annular radial flange **32** also has a second projection **35** facing the outer face **14***a* of the upstream tabs **14**, the second projection **35** extending from the inner face **32***a* of the upstream radial flange **32** over a distance that is shorter than that of the first projection **34**.

On the downstream side, the ring support structure has a downstream annular radial flange **36** with a projection **38** on its inner face **36***a* facing the downstream tabs **16** of the ring sectors **10**.

Furthermore, in the presently-described example, the ring sectors **10** are also retained by retention elements, specifically in the form of keepers **40**. The keepers **40** are engaged both in the downstream annular flange **36** of the ring support structure **3** and in the downstream tabs **16** of the ring sectors **10**. For this purpose, each keeper **40** passes through a respective orifice **37** formed in the downstream annular radial flange **36** and a respective orifice **17** formed in each downstream tab **16**, the orifices **37** and **17** being put into alignment when mounting the ring sectors **10** on the ring support structure **3**. The keepers **40** are made of a material having a coefficient of thermal expansion that is greater than the coefficient of thermal expansion of the ceramic matrix composite material of the ring sectors **10**. By way of example, the keepers **40** may be made of metal material. Clearance J2 is present when cold between the keepers **40** and the orifices **17** present in each downstream tab **16**. The expansion of the keepers **40** in the orifices **17** contributes to retaining the ring sectors **10** on the ring support structure **3** when hot.

In addition, sealing is provided between sectors by sealing tongues received in grooves that face each other in facing edges of two neighboring ring sectors. A tongue **22***a* extends over almost the entire length of the annular base **12** in its middle portion. Another tongue **22***b* extends along the tab **14** and over a portion of the annular base **12**. Another tongue **22***c* extends along the tab **16**. At one end, the tongue **22***c* comes into abutment against the tongue **22***a* and against the tongue **22***b*. By way of example, the tongues **22***a*, **22***b*, and **22***c* are made of metal and are mounted with clearance when cold in their housings so as to provide the sealing function at the temperatures that are encountered in operation.

In conventional manner, ventilation orifices **33** formed in the flange **32** allow cooling air to be delivered from the outside of the turbine ring **10**.

There follows a description of how a turbine ring assembly corresponding to that shown in FIG. **1** is made.

Each above-described ring sector **10** is made of ceramic matrix composite (CMC) material by forming a fiber preform of shape close to that of the ring sector and by densifying the ring sector with a ceramic matrix.

In order to make the fiber preform, it is possible to use yarns made of ceramic fibers, e.g. yarns made of SiC fibers such as those sold by the Japanese supplier Nippon Carbon under the name "Nicalon", or yarns made of carbon fibers.

The fiber preform is advantageously made by three-dimensional weaving or by multilayer weaving, while leaving zones of non-interlinking that enable the portions of the preforms that correspond to the tabs **14** and **16** to be moved away from the sectors **10**.

The weaving may be of the interlock type, as shown. Other three-dimensional or multilayer weaves could be used, such as for example multi-plain or multi-satin weaves. Reference may be made to Document WO 2006/136755.

After weaving, the blank may be shaped in order to obtain a ring sector preform that is then consolidated and then densified with a ceramic matrix, which densification may be performed in particular by chemical vapor infiltration (CVI), as is well known.

A detailed example of fabricating CMC ring sectors is described in particular in Document US 2012/0027572.

The ring support structure **3** is made of a metal material such as a Waspaloy®, Inconel 718, or AM1 alloy.

Assembly of the turbine ring assembly then continues by mounting ring sectors **10** on the ring support structure **3**. In the example described, the ring support structure has at least one flange that is elastically deformable in the axial direction DA of the ring, in this example the downstream annular radial flange **36**. While a ring sector **10** is being mounted, the downstream annular radial flange **36** is pulled in the direction DA as shown in FIG. **2** so as to increase the spacing between the flanges **32** and **36** and enable the first projection **34** present on the flange **32** to be inserted in the groove **140** present in the tab **14** without running the risk of damaging the ring sector **10**. In order to make it easier to move the downstream annular radial flange **36** away, it includes a plurality of hooks **39** that are distributed over its face **36***b* that faces away from the face **36***a* of the flange **36** facing the downstream tabs **16** of the ring sectors **10**. The traction exerted on the elastically deformable flange **36** in the axial direction DA of the ring is applied in this example by means of a tool **70** having at least one arm **71** with an end including a hook **510** that is engaged in a hook **39** present on the outer face **36***b* of the flange **36**. The number of hooks **39** distributed over the face **36***b* of the flange **36** is defined as a function of the number of traction points that it is desired to have on the flange **36**. This number depends mainly on the resilient nature of the flange. Other shapes and arrangements for the means that enable traction to be exerted in the axial direction DA on one of the flanges of the ring support structure may naturally be envisaged in the ambit of the present invention.

Once the annular flange **36** has been moved away in the direction DA, the free ends **141** and **161** of the tabs **14** and **16** are engaged respectively in the resilient attachment portions **521** and **531** of the resilient retention element **50**, firstly until the grooves **142** and **143** of the tab **14** co-operate respectively with the curved ends **5210** and **5211** of the resilient attachment portion **521**, and secondly until the grooves **162** and **163** of the tab **16** co-operate respectively with the curved ends **5310** and **5311** of the resilient attachment portion **531**. Once the projection **34** of the flange **32** has been inserted in the groove **140** of the tab **14**, and the curved ends **5210**, **5211**, **5310**, and **5311** have been received in the grooves **142**, **143**, **162**, and **163**, and the tabs **14** and **16** have been positioned so as to put the orifices **17** and **37** into alignment, the flange **36** is released. A keeper **40** is then engaged in the aligned orifices **37** and **17** formed respectively in the downstream annular radial flange **36** and in the downstream tab **16**. Each ring sector tab **14** or **16** may include one or more orifices for passing one or more keepers. The keepers **40** are tight fits in the orifices **37** in the downstream annular radial flange **36**, providing assemblies known as H6-P6 fits or other tight-fit assemblies enabling these elements to be held together when cold. The keepers **40** may be replaced by pegs or any other equivalent element.

When cold, the ring sectors **10** are retained by the resilient retention element **50**. When hot, the expansion of the resilient retention element **50** means that it can no longer ensure that the ring sectors are retained by the attachment portions **521** and **531**. Retention when hot is provided both by the expansion of the projection **34** in the groove **140** of the tab **14**, thereby absorbing or eliminating the clearance J1, and by the expansion of the keeper **40** in the orifice **17** of the tab **16**, thereby absorbing or eliminating the clearance J2.

FIG. **3** shows a variant embodiment of the high pressure turbine ring assembly that differs from the high pressure turbine ring assembly described above with reference to FIGS. **1** and **2** in that the inner and outer grooves **1142** and **1143** present at the end **1141** of the tab **114** of each ring sector **110** and the inner and outer grooves **1162** and **1163** present at the end **1161** of the tab **116** of each ring sector **110** are rectilinear in shape, and in that the curved ends **6210** and **6211** of the resilient attachment portion **621** present at the end of the first arm **62** of each resilient retention element **60** and the curved ends **6310** and **6311** of the resilient attachment portion **631** present at the end of the second arm **63** of each resilient attachment element **60** extend in a rectilinear direction. This makes it possible in particular to simplify the machining of the grooves in the tabs of the ring sectors. Under such circumstances, the resilient retention element **60** is made up of a plurality of segments. The other portions of the high pressure turbine ring assembly are identical to those described above with reference to the ring assembly shown in FIGS. **1** and **2**.

FIG. **4** shows a high pressure turbine ring assembly in another embodiment that differs from the ring assembly described above with reference to FIGS. **1** and **2** in that it uses different resilient retention elements or means. Like the above-described ring assembly, the FIG. **4** ring assembly comprises a turbine ring **201** made of ceramic matrix composite (CMC) material and a metal ring support structure **203**. The turbine ring **201** is made up of a plurality of ring sectors **210** and surrounds a set of rotary blades **205**. Each ring sector **210** presents a section that is substantially in the shape of an upside-down Greek letter Pi, or "π", with an annular base **212** having its inner face coated in a layer **213** of abradable material, and upstream and downstream tabs **214** and **216** extending from the outer face of the annular base **212** in the radial direction DR.

The ring support structure **203**, which is secured to a turbine casing **230**, has a resilient retention element or means **250** comprising a base **251** fastened to the inner face of the shroud **231** of the turbine casing **230**, and first and second arms **252** and **253** extending from the base **251** respectively upstream and downstream. With these two arms **252** and **253**, the resilient retention element **250** forms a C-clip type resilient attachment serving to retain the ring sectors **210** on the ring support structure **203** when cold. The first arm **252** has a curved attachment portion **2521** at its free end **2520**, which attachment portion extends in a rectilinear direction in this example. The curved attachment portion **2521** retains the free end **2141** of the upstream tab **214** of each ring sector **210**. The free end **2141** of the upstream tab **214** includes an outer groove **2143** arranged in the outer face **214***a* of the tab **214** and co-operating with the curved attachment portion **2521**, the groove **2143** in this example being rectilinear in shape. Likewise, the second arm **253** has a curved attachment portion **2531** at its free end **2530**, which attachment portion extends in a rectilinear direction and retains the free end **2161** of the downstream tab **216** of each ring sector **210**. The free end **2161** of the downstream tab **216** includes an outer groove **2163** arranged in the outer face **216***a* of the tab **216** and co-operating with the curved attachment portion **2531**, the groove **2163** in this example being rectilinear in shape.

The resilient retention element **250** may be made of a metal material such as a Waspaloy®, Inconel 718, or AM1 alloy. It is preferably made up as a plurality of annular sectors in order to make it easier to fasten to the casing **230**. The resilient retention element **250** serves to retain the ring sectors **210** on the ring support structure **203** when cold.

In the same manner as described above for the ring assembly of FIGS. **1** and **2**, the ring support structure **203** has an upstream annular radial flange **232** having a first projection **234** on its inner face **232***a* facing the upstream tabs **214** of the ring sectors **210**, the projection **234** being received in an annular groove **2140** present in the outer faces **214***a* of the upstream tabs **214**. Clearance J21 is present when cold between the first projection **234** and the annular groove **2140**. The expansion of the first projection **234** in the annular grooves **2140** contributes to retaining the ring sectors **210** on the ring support structure **203** when hot. The upstream annular radial flange **232** also has a second projection **235** facing the outer faces **214***a* of the upstream tabs **214**, the second projection **235** extending from the inner face **232***a* of the upstream radial flange **232** over a distance that is less than that of the first projection **234**. On the downstream side, the ring support structure has a downstream annular radial flange **236** having a projection **238** on its inner face **236***a* facing the downstream tabs **216** of the ring sectors **210**.

Furthermore, in the presently-described example, the ring sectors **210** are also retained by the retention elements, in this example in the form of keepers **240**. The keepers **240** are engaged both in the downstream annular flange **236** of the ring support structure **203** and in the downstream tabs **216** of the ring sectors **210**. For this purpose, each keeper **240** passes respectively through a respective orifice **237** formed in the downstream annular radial flange **236** and a respective orifice **217** formed in each downstream tab **216**. The keepers **240** are made of a material having a coefficient of thermal expansion that is greater than the coefficient of thermal expansion of the ceramic matrix composite material of the ring sectors **210**. The keepers **240** may for example be made of metal material. Clearance J22 is present when cold between the keepers **240** and the orifices **217** present in each downstream tab **216**. The expansion of the keepers **240** in the orifices **217** contributes to retaining the ring sectors **210** on the ring support structure **203** when hot.

In addition, sealing between sectors is provided by sealing tongues **222***a*, **222***b*, and **222***c* as described above. In conventional manner, ventilation orifices **233** formed in the flange **232** serve to bring cooling air from the outside of the turbine ring **201**.

Each ring sector **210** is made of ceramic matrix composite (CMC) material by forming a fiber preform of shape close to the shape of the ring sector and by densifying the ring sector with a ceramic matrix. The ring support structure **203** is made of a metal material such as a Waspaloy®, Inconel 718, or AM1 alloy.

When assembling a ring sector **210**, the downstream annular radial flange **236** is pulled in the direction DA as shown in FIG. **5** so as to enable the first projection **234** present on the flange **232** to be inserted in the groove **2140** present in the tab **214** without running the risk of damaging the ring sector **210**. In order to facilitate moving the downstream annular radial flange **236** away by traction, it includes a plurality of hooks **239** distributed over its face **236***b*, which face is opposite from the face **236***a* of the flange **236** that faces the downstream tabs **216** of the ring sectors **210**. The traction in the axial direction DA of the ring exerted on the elastically deformable flange **236** is performed in this example by means of a tool **270** having at least one arm **271** with its end including a hook **2710** that is engaged in a hook **239** present on the outer face **236***a* of the flange **236**.

Once the annular flange **236** has been moved away in the direction DA, the free ends **2141** and **2161** of the tabs **214** and **216** are engaged between the ends **2520** and **2530** of the resilient retention element **250** until the groove **2143** of the tab **214** and the groove **2163** of the tab **216** co-operate respectively with the curved attachment portions **2521** and **2531** of the resilient retention element **250**. Once the projection **234** of the flange **232** is inserted in the groove **2140** of the tab **214**, and the curved attachment portions **2521** and **2531** are positioned in the grooves **2143** and **2163**, and said tabs **214** and **216** are positioned so as to put the orifices **217** and **237** in alignment, the flange **236** is released. A keeper **240** is then engaged in the aligned orifices **237** and **217** formed respectively in the downstream annular radial flange **236** and in the downstream tab **216**. Each tab **214** or **216** of the ring sector may include one or more orifices for passing one or more keepers. The keepers **240** are tight fits in the orifices **237** of the downstream annular radial flange **236** providing assemblies known as H**6**-P**6** fits or other tight assemblies enabling these elements to be held together when cold. The keepers **240** may be replaced by pegs or any other equivalent element.

When cold, the ring sectors **210** are retained by the resilient retention element **250**. When hot, the expansion of the resilient retention element **250** means that it can no longer ensure that the ring sectors are retained by the curved attachment portions **2521** and **2531**. Retention when hot is provided both by the projection **234** expanding in the groove **2140** of the tab **214**, thereby absorbing or eliminating the clearance J**21**, and by the expansion of the keeper **240** in the orifice **217** in the tab **16**, thereby absorbing or eliminating the clearance J**22**.

FIG. **6** shows a high pressure turbine ring assembly in another embodiment. Like the ring assemblies described above, the FIG. **6** ring assembly comprises a turbine ring **301** made of ceramic matrix composite (CMC) material and a metal ring support structure **303** secured to a turbine casing **330**. The turbine ring **301** is made up of a plurality of ring sectors **310** and surrounds a set of rotary blades (not shown in FIG. **6**). Each ring sector **310** is in the shape of the letter K with an annular base **312** having its inner face coated in a layer **313** of abradable material to define the passage for the gas stream flow through the turbine. A first tab **314** and a second tab **316**, both substantially in the shape of the letter S, extend from the outer face of the annular base **312**.

The ring support structure **303** has an upstream annular radial flange **332** with a first projection **334** on its inner face **332***a* facing the upstream tabs **314** of the ring sectors **310**, the projection **334** being received in annular grooves **3140** present in the ends **3141** of the upstream tabs **314**. Clearance J**31** is present when cold between the first projection **334** and the annular groove **3140**. The expansion of the first projection **334** in the annular grooves **3140** contributes when hot to retain the ring sectors **310** on the ring support structure **303**. The upstream annular radial flange **332** also has a second projection **335** that projects under the ends **3141** of the upstream tabs **314**.

On the downstream side, the ring support structure has a downstream annular radial flange **336** with a projection **338** on its outer face **336***b*. The annular radial flange **336** also has arms **339**, there being two arms per ring sector in this element, which arms extend radially beside the outer surface of the flange **336**. Each arm **339** includes an orifice **3391** at its free end **3390**.

The ring assembly also has C-clip type resilient retention elements or means **350**, each having a first resilient attachment portion **352** and a second resilient attachment portion **353**. The resilient retention elements **350** serve, when cold, to retain the ends **3161** of the downstream tabs **316** of the ring sectors **310** against the projection **338**, stress being exerted on its two portions respectively by the end **3520** of the first resilient attachment portion **352** and the end **3530** of the second resilient attachment portion **353** of each resilient retention element **350**. The resilient retention element **350** may be made of a metal material such as a Waspaloy®, Inconel 718, or AM1 alloy.

Furthermore, in the presently-described example, the ring sectors **310** are also retained by retention elements, in this example in the form of pegs **340**. The pegs **340** are engaged both in the arms **339** of the downstream annular flange **336** of the ring support structure **303** in the resilient retention elements **350**, and in the downstream tabs **316** of the ring sectors **310**. For this purpose, each peg **340** passes through a respective orifice **3391** formed in each arm **339** present on the downstream annular radial flange **3236**, a respective orifice **355** formed in each resilient retention element **350**, and a respective orifice **317** formed in each tab **316**. The pegs **340** are made of a material having a coefficient of thermal expansion greater than the coefficient of thermal expansion of the ceramic matrix composite material of the ring sectors **310**. By way of example, the pegs **340** may be made of a metal material. Clearance J**32** is present when cold between the pegs **340** and the orifices **317** present in each downstream tab **216**. When hot, the expansion of the pegs **340** in the orifices **317** contributes to retaining the ring sectors **310** on the ring support structure **303**.

Each ring sector **310** is made of ceramic matrix composite (CMC) material by forming a fiber preform of shape close to that of the ring sector and by densifying the ring sector with a ceramic matrix. The ring support structure **303** may be made of a metal material such as a Waspaloy®, Inconel 718, or AM1 alloy.

During assembly of the ring sector **310**, as shown in FIG. **7**, the first projection **334** present on the flange **332** is engaged in the groove **3140** present in the tab **314**. The end **3161** of the tab **316** of each ring sector **310** is pressed against the projection **338** present at the end of the annular flange **336**. Once the projection **334** is inserted in the groove **3140** and the end **3161** is pressed against the projection **338**, the resilient attachment elements **250** are positioned between the end **3161** and the projection **338**, the end **3520** of the first resilient attachment portion **352** being in contact with the projection **338**, and the end **3530** of the second resilient attachment portion **353** of each resilient retention element **350** being in contact with the end **3161** of the tab **316**. When cold, the resilient elements **350** serve to retain the end **3161** of the tab **316** of each ring sector **310** against the projection **338** of the annular flange **336**.

A peg **340** is then engaged in each aligned series of orifices **3391**, **355**, and **317** formed respectively in each arm **339** present on the downstream annular radial flange **336**, in a resilient retention element **350**, and in the tab **316**. The pegs **340** are tight fits in the orifices **3391** in each arm **339** being assembled by H**6**-P**6** fits or other tight-fit assemblies that enable these elements to be held together when cold. The pegs **340** may be replaced by keepers or any other equivalent element.

When cold, the ring sectors **310** are retained by the resilient retention element **350**. When hot, the expansion of the resilient retention element **350** means that it no longer serves to retain the ring sectors by the resilient attachment portions **352** and **353**. Retention when hot is provided both by the expansion of the projection **334** in the groove **3140** of the tab **314**, which absorbs or eliminates the clearance J**31**, and by the expansion of the pegs **340** in the orifices **317** of the tabs **316**, thereby absorbing or eliminating the clearance J**32**.

The turbine ring assembly of FIGS. **6** and **7** is described with ring sectors presenting a section that is K-shaped. Nevertheless, this embodiment applies equally well to ring sectors having a section that is substantially in the shape of an upside-down Greek letter π, like those shown in FIGS. **1** to **5**. Likewise, the embodiments of the turbine ring assembly described with reference to FIGS. **1** to **5** are equally applicable to ring sectors presenting a section that is K-shaped.

The invention claimed is:

1. A turbine ring assembly comprising a plurality of ring sectors made of ceramic matrix composite material forming a turbine ring and a ring support structure having first and second annular flanges, each ring sector having an annular base forming portion having an inner face defining the inside face of the turbine ring and an outer face from which there extend first and second tabs, the tabs of each ring sector being retained between the first and second annular flanges of the ring support structure;

wherein the first tab of each ring sector includes an annular groove in its face facing the first annular flange of the ring support structure, the first annular flange of the ring support structure including an annular projection on its face facing the first tab of each ring sector, the annular projection of the first annular flange being received in the annular groove of the first tab of each ring sector, clearance being present when cold between the annular projection and the annular groove;

wherein at least the second tab of each ring sector is connected to the ring support structure by at least one first resilient retention element; and

wherein the second tab of each ring sector includes at least one opening in which there is received a portion of a second retention element secured to the second annular flange of the ring support structure, clearance being present when cold between the opening in the second tab and the portion of the second retention element present in said opening, said second retention element being made of a material having a coefficient of thermal expansion that is greater than a coefficient of thermal expansion of the ceramic matrix composite material of the ring sectors.

2. The assembly according to claim **1**, wherein each ring sector is Pi-shaped in axial section, the first and second tabs extending from the outer face of the annular base forming portion, and wherein the at least one first resilient retention element comprises a base fastened to the ring support structure and from which first and second arms extend, each of the first and second arms including a C-clip type resilient attachment portion at a free end of the first and second arms, a free end of the first tab of each ring sector being retained by the resilient attachment portion of the first arm, while a free end of the second tab of each ring sector is retained by the resilient attachment portion of the second arm of the at least one first resilient retention element.

3. The assembly according to claim **2**, wherein the first tab of each ring sector includes an outer groove and an inner groove co-operating with the C-clip type resilient attachment portion of the first arm of the at least one first resilient retention element, and wherein the second tab of each ring sector includes an outer groove and an inner groove co-operating with the C-clip type resilient attachment portion of the second arm of the first resilient retention element.

4. The assembly according to claim **3**, wherein the inner and outer grooves of the first and second tabs of each ring sector present a radius of curvature similar to a radius of curvature of the C-clip type resilient attachment portions of the first and second arms of the at least one first resilient retention element.

5. The assembly according to claim **3**, wherein the inner and outer grooves of the first and second tabs of each ring sector are rectilinear in shape, and wherein the C-clip type resilient attachment portions of the first and second arms of the at least one first resilient retention element extend along a straight line.

6. The assembly according to claim **1**, wherein each ring sector is Pi-shaped in axial section, the first and second tabs extending from the outer face of the annular base forming portion, and wherein the at least one first resilient retention element comprises a base fastened to the ring support structure and from which there extend first and second arms together forming a C-clip type resilient attachment portion, a free end of the first tab of each ring sector being retained by the first arm, while a free end of the second tab of each ring sector is retained by the second arm of the at least one first resilient retention element.

7. The assembly according to claim **6**, wherein the first tab of each ring sector includes an outer groove co-operating with a free end of the first arm of the at least one first resilient retention element, and wherein the second tab of each ring sector includes an outer groove co-operating with a free end of the second arm of the at least one first resilient retention element.

8. The assembly according to claim **7**, wherein the outer grooves of the first and second tabs of each ring sector are rectilinear in shape, and wherein the free ends of the first and second arms of the at least one first resilient retention element extend along a straight line.

9. The assembly according to claim **1**, wherein each ring sector presents a K-shape in axial section, the first and second tabs extending from the outer face of the annular base forming portion, the first tab having an annular groove at a first end opposite the annular base forming portion in which there is received the annular projection of the first annular flange, and wherein the second tab of each ring sector is connected to the second annular flange via the at least one first resilient retention element.

10. The assembly according to claim **9**, wherein the second tab of each ring sector is connected to the second annular flange of the ring support structure by at least one clip element formed by the at least one first resilient retention element.

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